# Noncoincident Validation of Aura MLS Observations Using the Langley Research Center Lagrangian Chemical Transport Model

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**Introduction:**

- We use the LaRC Lagrangian Chemistry and Transport Model (LCTM) [Pierce et al., 2003; Pierce et al., 1999] for "noncoincident validation" of Aura MLS observations of O3, HCl, and H2O.
- Our preliminary study utilizes HALOE obs only. Use of ACE and other occultation data sets planned. Comparison with other Aura data also.
- Here we focus on November 28, 2004 comparisons, due to the previous 3-week period of continuous HALOE observations with which to initialize LCTM.
- The LCTM calculates the transport, mixing, and photochemical evolution of an ensemble of parcels that have been initialized from measurements.
- DAS-driven transport and relatively short trajectory lifetimes promotes strong influence of initializing observations on subsequent LCTM constituent distributions.
- Relatively large number of model parcels allows single-day comparisons with Aura which complements standard coincident validation techniques.

**LaRC LCTM Model Description**

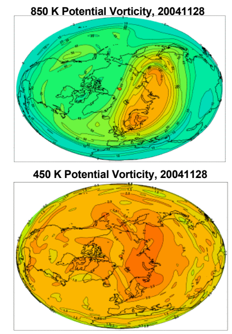
- Model tracks transport, mixing, and photochemical evolution of parcels initialized from observations.
- NASA GEOS-4 DAS meteorological data.
  - 1.25º lon x 1º lat x 55 eta levels, .01 hPa top.
- 6-hour average horizontal winds and vertical pressure velocity from DAS to kinematically advect parcels.
- Parcels initialized from HALOE observations of O3, CH4, H2O, HCl, NO, NO2, HF and aerosols.
- Other species in standard stratospheric chemical mechanism initialized using parcel θ, CH4, and model climatology mapped to θ and CH4
- Overhead column O3 obtained from GEOS-4 DAS PV and PV/Aura MLS O3 mapping for each run day.
- Kawa lookup table photolysis parameterization.
- Interparcel mixing parameterization [Fairlie et al., 1999] included.
- Type 1 and Type 2 PSC Parameterization included.

**References**

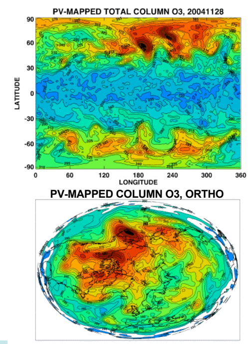
- Fairlie, T. D., et al., J. Geophys. Res., 104, 26,597-26,609, 1999.
- Pierce, R. B., et al., J. Geophys. Res., 104 (D21), 26,525-26,545, 1999.
- Pierce, R.B., et al., J. Geophys. Res., 108 (D5), 8317, doi:10.1029/2001JD001063, 2003.

**Run Description:**

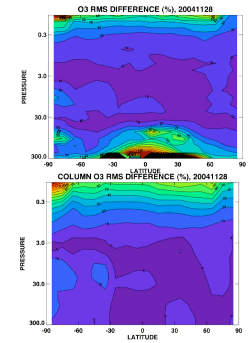
- Run dates: 11/8/2004 - 11/28/2004.
- ~11000 parcels initialized during this time.
- HALOE v19 data interpolated to 22 theta levels between 350-2000 K prior to initialization (procedure for computational efficiency which allows longer model runs). Only HALOE parcels north of 30S initialized (my bad - but shouldn't adversely affect NH results).
- Parcels only initialized when all observed species have signal/noise ratio > 0.3.
- Parcel diagnostics output every 6 hours, allowing a ± 3 hour time window for comparison to Aura observations.
- LCTM output compared to v1.51 MLS obs.



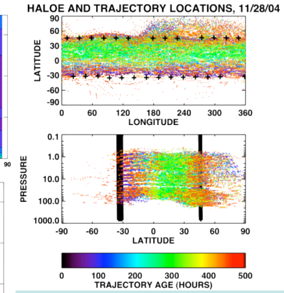

Plots of GEOS4-DAS PV on the 450 K and 850 K surfaces show a developing polar vortex on 11/28/04 that is reasonably well-defined at 850 K and poorly defined at 450 K.



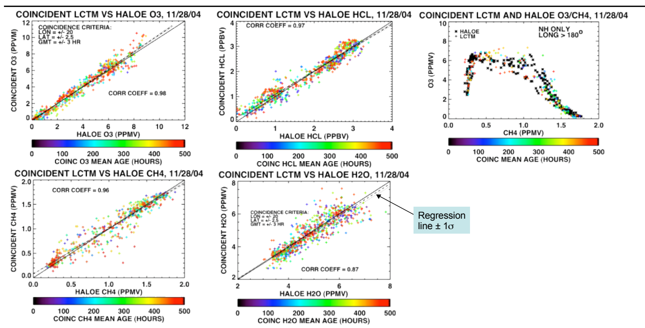

We used Aura MLS O3 and GEOS4-DAS PV to develop a high resolution (1.25 lon x 1 lat), cloud-cleared, overhead column O3 field for LCTM photolysis calculations.



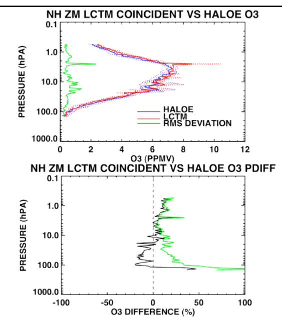

PV-mapped O3 agrees very well with MLS O3. These figures show root-mean-square differences between MLS PV-mapped O3 (above) and overhead column (below).



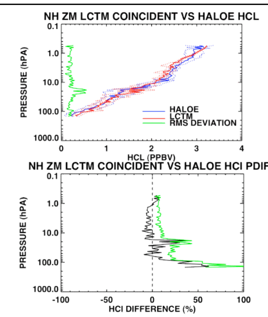

LCTM trajectory locations on 11/28/04, colored by trajectory age. Simulation starts on 11/8/04. Parcels are initialized at locations and times of HALOE observations and propagated forward. Oldest and youngest parcels are in NH and SH mid to high latitudes, medium-aged parcels are in tropics and NH subtropics. Crosses show locations of HALOE observations on 11/28/04. Note parcel deficit in NH vortex.



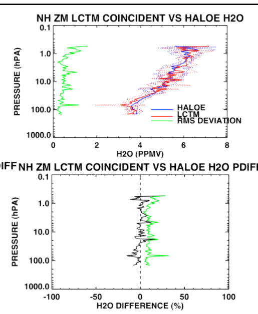

A key question is whether the LCTM, initialized from HALOE data, agrees with subsequent HALOE measurements. These figures show the correlations between HALOE observations made on 11/28/04 with mean values of all LCTM parcels (initialized from previous HALOE observations) coincident to the 11/28/04 HALOE obs. Coincident values are colored by mean age of parcels. O3 and HCl show tight correlations. CH4 correlation is high at low (high altitude) and high (low altitude) mixing ratios. H2O correlations are weaker than the others. The observed O3/CH4 correlation outside of the vortex is reproduced well.



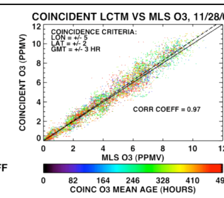

Top shows NH zonal mean O3 comparison of HALOE observations on 11/28/04 and zonal mean of coincident LCTM output. Dotted lines show standard deviation range and green line is root-mean-square deviation of HALOE & LCTM. LCTM is high-biased above ~20 hPa, low-biased below. Deviations range up to ~30% above 100 hPa.



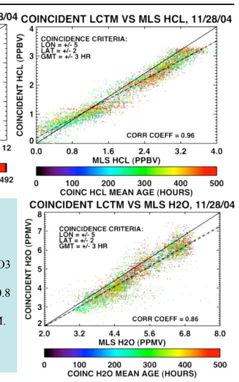

As in previous figure, for HCl. LCTM is slightly low biased above ~20 hPa, and high-biased below 100 hPa. Deviations increase to over 50% at altitudes below 100 hPa.

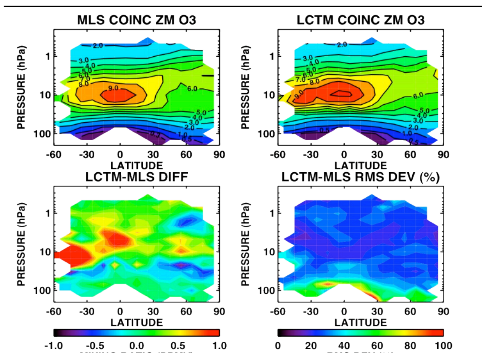



As in previous figure, for H2O. LCTM agrees very well from ~200 to 0.8 hPa. RMS deviation are ~10-20% throughout vertical range.

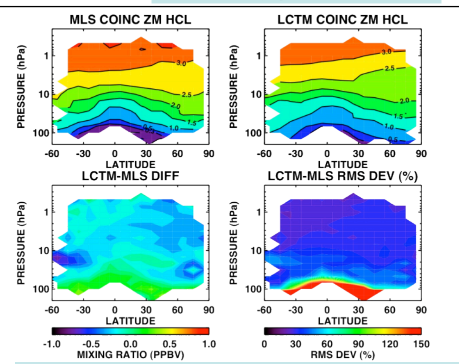



LCTM comparisons with MLS observations on 11/28/04. The large number of MLS observations yields many more coincidences over a broad latitude range than with HALOE. The O3 correlation shown above appears tight and unbiased. Both MLS HCl above ~0.8 ppbv and MLS H2O are high-biased compared to HALOE-initialized LCTM. The H2O correlations are weaker than either HCl or O3, as with HALOE/LCTM comparisons.

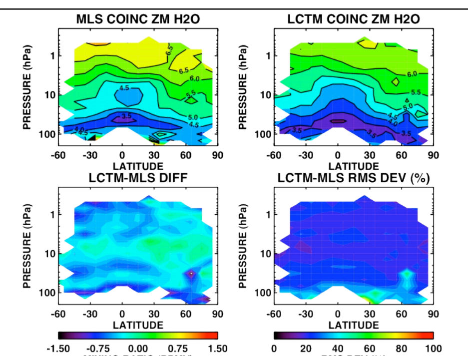



This figure compares zonal mean O3 distributions constructed using only coincident MLS observations and LCTM parcels on 11/28/04. Bottom left shows mixing ratio difference and bottom right shows rms differences. SH biases are larger than NH. RMS deviations exceed 50% in LS, with largest deviations in tropics.




Differences between ZM of coincident MLS (top left) and coincident LCTM (top right) range between ±1 ppbv (bottom left), and shows some latitudinally and vertically-varying structure. LCTM is mostly low-biased above UT/LS region, with generally larger low-biases in NH. LCTM is neutral to high-biased in UT/LS. RMS deviations are generally 20%-30% except at low altitudes in tropics and subtropics, where deviations exceed 100%.




LCTM coincident H2O (top right) is mostly low-biased compared to coincident MLS observations (top left). Tropics and SH are more low-biased than NH mid and higher lats, though there is an interesting large low-bias (albeit with large rms deviations) at low altitudes in NH mid to high lats. RMS deviations are generally small elsewhere. MLS obs show a tropical double minimum which is not reproduced in LCTM. It is not yet clear why.

**Conclusions**

- HALOE-initialized LCTM run for 20 days successfully predicts subsequent HALOE measurements of O3, HCl, CH4, and H2O, suggesting utility for non-coincident validation of Aura data.
- HALOE-initialized LCTM O3 agrees well with Aura MLS O3. LCTM HCl and H2O are low-biased with respect to Aura MLS and H2O.
- Results are consistent with standard validation comparisons of HALOE HCl, H2O, and O3 with MLS observations.
- Future plans include incorporating ACE and POAM occultation observations, examining other times during 2004-2005, upgrading model parameterizations, and using model to understand relative contribution of photochemistry, heterogeneous chemistry, mixing, and transport on constituent evolution.